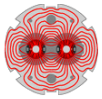
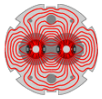


BNL -FNAL - LBNL - SLAC

LARP CM18
May 7-9, 2012
FNAL

Cable Insulation for LHQ and Prototype

Arup K. Ghosh (BNL)



Outline

- Report on discussion at the WG
  - Insulation options
    - Near term plans
    - Open issues
  - Rad Hard Epoxy
    - Cyanate Ester
    - Matrimid

Insulation Options

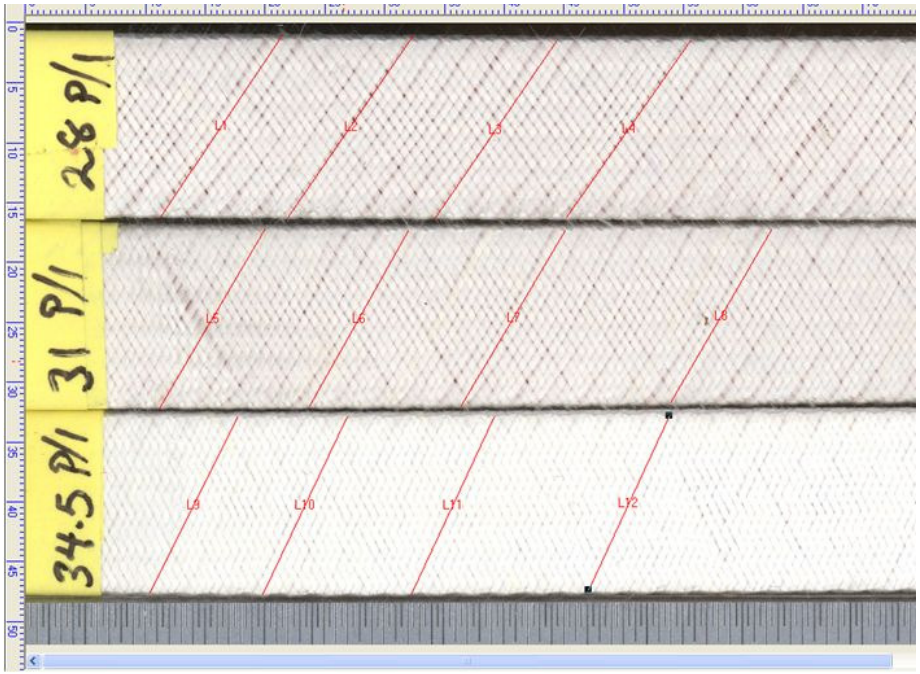
- Braided Insulation at NEWC
  - Initial development : 10 mm wide LQ cable using S-2 glass with 636 binder
    - Reaction at 640C leaves a lot of carbon residue
  - Recent trials used S-2 glass with Silane binder 933
    - Product literature: 933 sizing is stable at processing of temperature of 670°F and above
    - Trials at LBNL show that 2% by weight is lost by heat treating at 665C
    - CERN is also experimenting with braiding similar yarn.
    - Tests at CERN to 550C show no decomposition of the binder. Tests will be extended to higher temperatures

S-2 glass with 933 binder

agy

High Temperature
933 S-2 Glass® Yarn

- Recent trials with AGY 75 1/0 yarn braided on HQ 15 mm wide cable
- Target 100 mm for HQ and LHQ coils.
- First Trial ~ 30 m



Thickness Meas.
Using 10-stacks

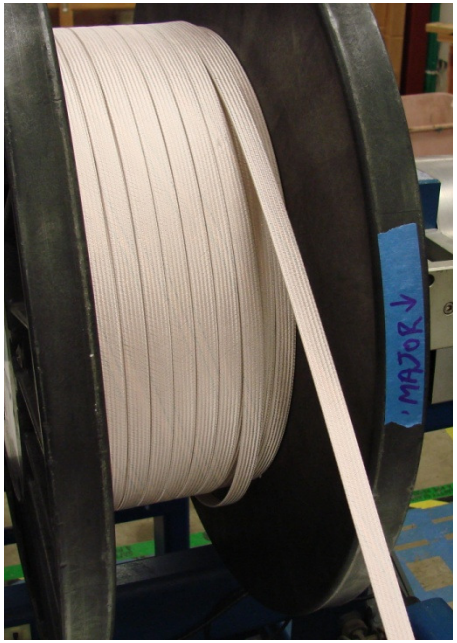
103 μm

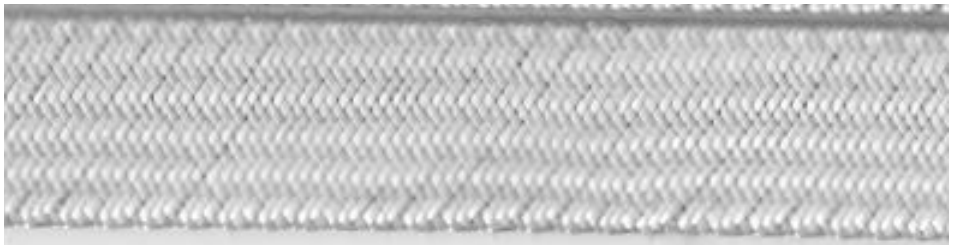
109 μm

114 μm

Braided Insulation

- 2nd trial : 100 m of HQ cable
  - Using braiding parameters to yield 100 μm thickness
  - 10-stack measurements at 6 MPa (1 KSI) 103 μm
  - Cable used to wind HQ-C17 . Coil is being readied for reaction at BNL

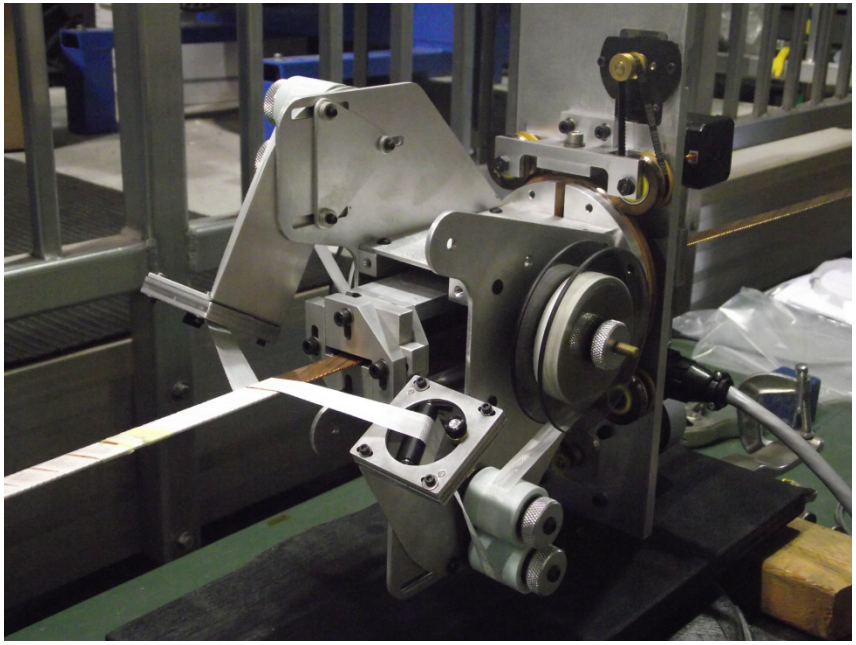




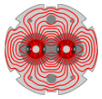
- Plan is to insulate 2 unit lengths of cable for the first two practice coils for LHQ, cable length ~ 320 m.
  - Capture braiding process and QA checks at vendor to ensure a good and reproducible product.

Tape Insulation

- Option to use E-glass (75 μm thick), S2-glass (150 μm thick), Al2O3-SiO2
- Tape insulation typically will produce insulation thickness in the range of 125-150 μm, half over-lap or double butt-wrap.
- For the 11 T model magnet FNAL is using E-glass tape wrap for cable insulation. Prior use in a TQ coil was quite successful.



LBL Tape wrapping line



Rad-Hard Epoxy

- Some options:
  - Cyanate Ester (CTD-403)
  - Cyanate Ester / Epoxy Blend (CTD-425)
  - Matrimid 5292
  - Any others??
- New materials need to be qualified:
  - Make and test 10-stacks.
  - Compare with current epoxy - CTD-101k:
    - Electrical
    - Mechanical
    - Cryogenic
- Use same tooling or replicate for use at another lab.
  - Need to be consistent in sample prep and testing in order to make accurate comparisons.

I. Schmalzle 4/8/12 LARP CM18 7

Rad-Hard Epoxy

- Matrimid has issue with temperature / viscosity
  - High working temperature – 125 C/ short pot life ~ 60 mins
  - High cure temperature – 200 - 250 C
  - Lines need to be actively heated to prevent solidification / blocked lines.
- CTD-425 – Epoxy / Cyanate Ester Blend (60 / 40).
  - Mixing / Processing Temperature 45-60 C
  - Cure: Slow ramps, 22 hours at 100 C, 24 hours at 170 C.

Rad-Hard Epoxy

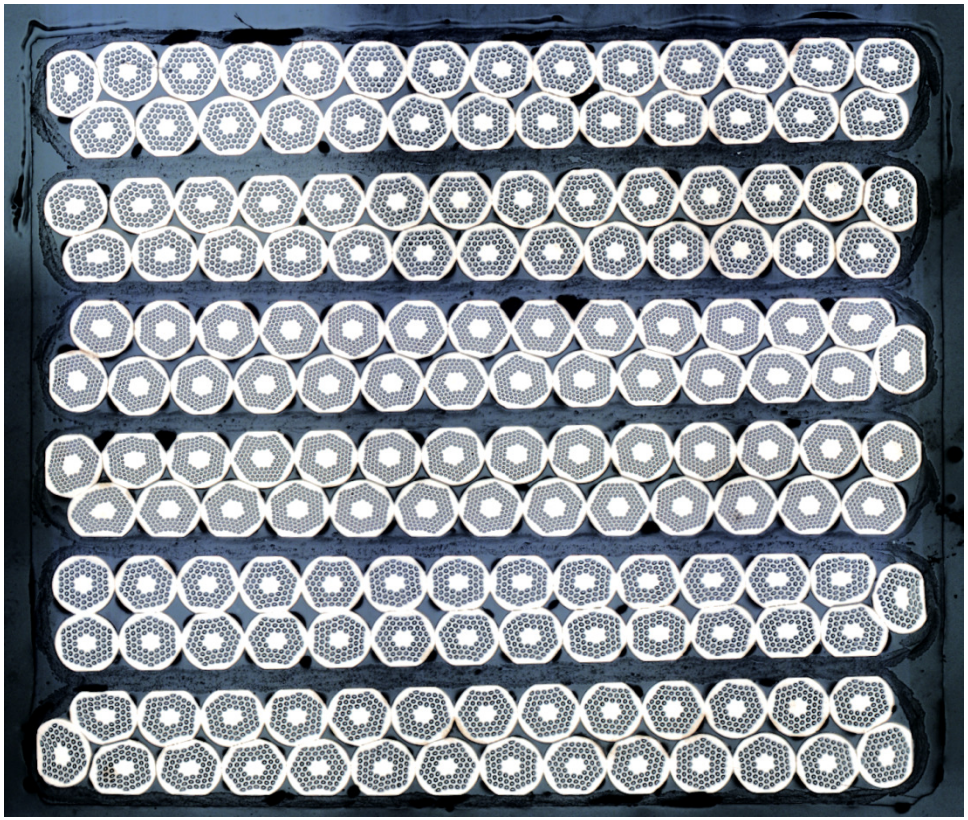
- Cyanate Ester / Blends have safety issues with possible exothermic reaction.
  - Need precise control of epoxy temperature from mixing through impregnation.
    - Additional TC's on impreg. fixture, some deep close to the coil not just on surface as now.
    - Need to establish control system for epoxy pot during mixing, de-gassing and impregnation.
  - Need ability to cool epoxy pot.
  - May need ability to cool impregnation fixture.
  - ITER is using blend CTD-425.
    - Can we learn from them about how to handle material safely.

Matrimid Investigation at FNAL

Steve Krave,
Rodger Bossert
Marianne Bossert

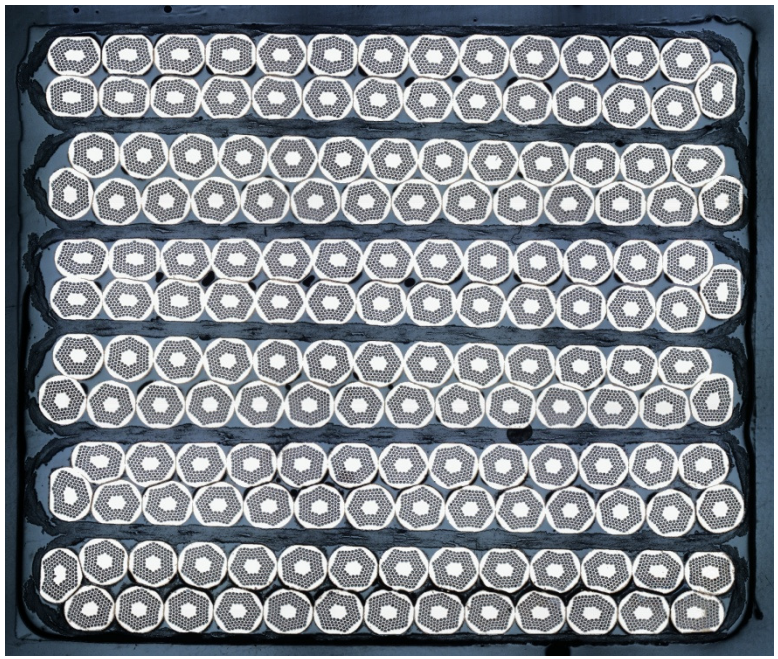
- Building on previous experience
- Developed tooling to impregnate 36” coil stacks
- Successful impregnation of 36” cable stacks
- Follow-up with impregnating a TQ Coil
- Plan to Use 10-stack for material characterizations at room temp and 77K(or 4.2K)
  - TQ cable with Cynate Ester*, Matrimid and CTD
  - HQ cable
  - 11 T cable
- Two TQ 10- stacks have been completed and are awaiting testing:
  - TQ-Matrimid and TQ-CTD101k

Potting with CTD-101

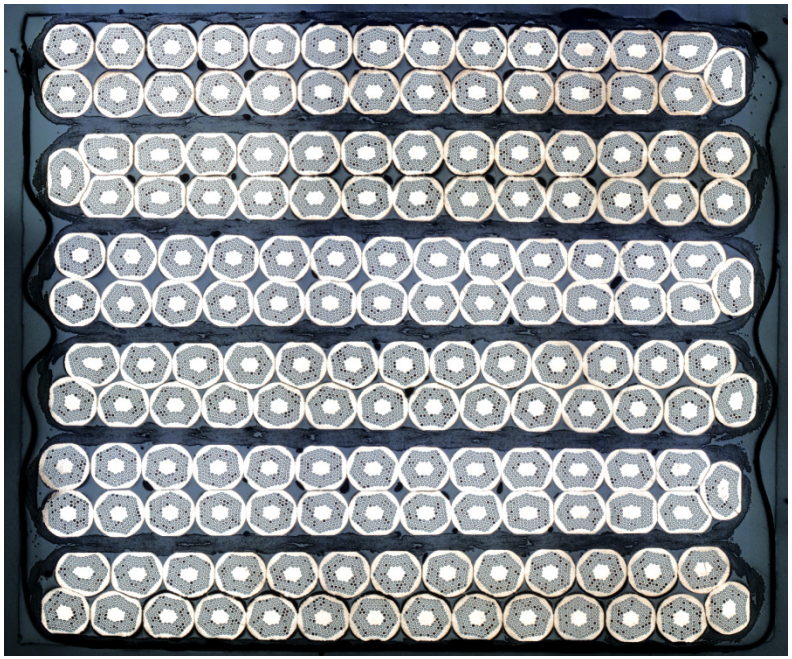


Matrimid Potted Samples

Cure at 200C



Cure at 250C



Summary

- For the LHQ present plan is to braid using S-2 glass with 933 binder
- Reliability of process at vendor is yet to be established

- Development of Rad-hard Epoxy
  - BNL developing impregnation with Cyanate Ester CTD-425
    - Drawback is one of handling, tempearture control
  - FNAL is investigating Matrimid
    - Drawback is short pot-life and higher cure temperatures
  - 10-stack measurements for demonstrating mechanical and electrical properties at RT and at cryogenic temperatures